International Journal of Gastrointestinal Intervention

journal homepage: www.ijgii.org

Review Article

Technical review of gastric per-oral endoscopic myotomy

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ABSTRACT

Gastroparesis, or symptomatic delayed gastric emptying, has seen a startling increase in prevalence of over last decade. Efficacy of initial dietary and medical therapies remain limited and patients that fail these first line remedies represent a significant therapeutic challenge. Recent procedural and technological advancements have led to the development of a promising endoscopic therapy for gastroparesis via an endoscopic pyloromyotomy, also referred to as gastric per-oral endoscopic myotomy (G-POEM) or per-oral endoscopic pyloromyotomy (POP). While initial preliminary reports of G-POEM or POP for the treatment of gastroparesis are encouraging, there is not a consensus standardized procedural approach and published practice patterns at each stage of the G-POEM procedure can vary wildly. The aim of our review is to provide an overview of the technical aspects of the G-POEM procedure framed within our current practice patterns and that of the published literature.

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Keywords: Endoscopy; Gastroparesis; G-POEM; Pyloromyotomy

Introduction

Gastroparesis, or delayed gastric emptying in the absence of mechanical obstruction, has seen a startling increase in prevalence of over last decade.^{1,2} Associated with the constellation of abdominal pain, nausea, vomiting, bloating, abdominal fullness and early satiety, gastroparesis is most commonly idiopathic in nature, although it has also been seen in a multitude of diseases ranging from diabetes, vagal nerve injury from foregut and thoracic surgery and connective tissue diseases.³ The primary treatment aim in gastroparesis is for palliation of symptoms and to promote increased gastric motility.³

However, medical therapies for gastroparesis are unfortunately limited by either waning efficacy or medication side effects.³ Chronic use of the only U.S. Food and Drug Administration approved medication for gastroparesis, metoclopramide, is hampered by the development of significant neurologic sequelae and additional medical options such as erythromycin, domperidone and cisapride are as similarly limited, either due to the development of tachyphylaxis, cardiovascular concerns, or a lack of wide spread availability.^{4–7}

While the underlying pathophysiologic process behind gastroparesis is unclear, subsequent investigators have identified that a

subset of gastroparetics possess a significant number of high amplitude pyloric contractions.^{8–10} This ‘pylorospasm’ has been a focal point for novel therapeutic interventions in patients that have failed medical therapy. These pyloric directed therapies range from pyloric botulinum toxin injection, to pyloric dilatation and stenting, to surgical pyloromyotomy.^{11–17} However, wide spread adoption of these techniques have been limited by either inconsistent efficacy, lack of long-term durability or the invasiveness of the procedure.¹⁸ With the recent advent of endoscopic submucosal tunneling and the success in utilizing this technique coupled with an endoscopic myotomy for the treatment of achalasia (per-oral endoscopic myotomy [POEM]), many providers have hypothesized that a similar technique could be employed for use in patients with gastroparesis.^{19–22} Following the initial description of the first human gastric per-oral endoscopic pyloromyotomy (G-POEM or POP) in 2013, over a dozen published studies of over 200 patients has demonstrated significant early therapeutic promise of G-POEM for the treatment of medically refractory gastroparesis.^{22–33}

Despite increasing reports of the G-POEM procedure, there is not a widely accepted standardized procedural approach and published practice patterns at each stage of the G-POEM procedure can vary wildly. The aim of our review is to provide an overview of the technical aspects of the G-POEM procedure framed within

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Received June 14, 2019; Revised July 20, 2019; Accepted July 20, 2019

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our current practice patterns and that of the published literature.

Procedure Description

The G-POEM procedure largely follows similar steps to that of an esophageal endoscopic myotomy^{19,20} and is divided into 5 steps: 1) Initial endoscopic inspection and pre-procedural testing; 2) Mucosotomy; 3) Submucosal tunnel formation with extension to the pyloric ring; 4) Myotomy of the pyloric muscle; and 5) Mucosotomy closure (Fig. 1).

Initial endoscopic inspection

Immediately prior to the G-POEM procedure, a full endoscopic inspection of esophagus, stomach and small intestine is performed to rule out alternative organic pathology that could explain delayed gastric emptying (i.e., stricture or mass) or to identify any contraindication to creation of a submucosal incision.

The most common abnormality we have identified that limits successful initiation of the G-POEM procedure is the presence of significant intragastric food material. Secondary to the nature of gastroparesis, the typical 8 to 12 hours window from *nil per os* status prior to the procedure is typically not sufficient to promote complete gastric clearance. Due to this, we recommend utilizing a 2 to 3 days period of liquids preceding the procedure in order to ensure the stomach is free from undigested particulate matter that is not amendable to endoscopic lavage and removal. Other authors have reported similar difficulties and they have recommended a similar waiting period.^{26,27}

Prior to the procedure, antibiotics are commonly employed (in 8 of 12 of the largest published G-POEM reports, with one noting IV antibiotics following the procedure).^{23–25,28,30–33} The majority of these studies utilize IV peri-procedural antibiotics with two noting use of gentamicin antibiotic washes. Three studies^{26,27,29} did not endorse use of periprocedural antibiotics.

Additionally, at our institution pyloric distensibility is obtained prior to the procedure via utilization of a 325/8 cm sized endoscopic Functional Lumen Imaging Probe (EndoFLIP; Medtronic, Sunnyvale, CA, USA). There have only been two detailed published reports on utilizing the EndoFLIP device for use in the G-POEM procedure.^{28,29} Jacques et al²⁹ noting that at 50 mL, a distensibility index of < 9.2 was 100% specific and 72.2% sensitivity in regards to the clinical efficacy of G-POEM and we

utilize this cutoff in selection of patients that may benefit from a G-POEM.²⁹ To facilitate passage of the balloon we commonly grasp the distal end of the device with a snare and drive the catheter into the duodenum.

Mucosotomy

Following successful endoscopic inspection, a gastroscope (GIF-H190 or GIF-H1T190; Olympus, Tokyo, Japan) is fitted with a transparent distal cap attachment (MH-588; Olympus) and the location of the mucosotomy site is identified. Significant variability exists in definitive determination for the site of the mucosotomy across the literature with both utilization of the lesser and greater curvature anatomic sites, approximately 2 to 5 cm proximal to the pylorus.^{23–33}

The location of the mucosotomy site largely appears to be provider dependent as those from a surgical background appear to favor the lesser curvature,^{26,27} with gastroenterologists largely favoring the greater curvature^{30,31} although again wide variability is noted. It is unknown if this practice is stylistic or conveys any potential therapeutic benefit or reduction in adverse events.

With the site of the mucosotomy identified and cleaned of debris, endoscopic injection of lifting solution is then employed. Methylene blue solution is the most commonly employed lifting solution used,^{25–27,30,31,33} although isolated reports of 1:10,000 epinephrine,²³ glycerol,²⁹ saline,²⁵ and indigo carmine solution³² have also been reported. However, in long term animal studies methylene blue has demonstrated some potential carcinogenic activity³⁴ and it is our practice to utilize a 0.25% indigo carmine into 500 mL HESPERAN (6% Hetastarch in 0.9% Sodium Chloride) solution secondary to these concerns. The desired amount of injectate required is analogous to the amount of injectate required to provide sufficient 'lift' in endoscopic mucosal resection and POEM, typically 4 to 6 mL.

Following injection of the lifting solution, mucosotomy is performed using an endoscopic needle knife. Numerous endoscopic needle knife devices (Fig. 2) exist but the most commonly employed are the triangle-tip knife (KD-640L; Olympus),^{23,24,27–29,32} hybrid knife (ERBE, Tübingen, Germany),^{25,28–31,33} or a hook knife (KD-620LR; Olympus).^{29,30} The selection of knife is largely stylistic although we do note several advantages to the most commonly employed knives. The triangle tip provides excellent tissue manipulation particularly of the antral stomach and muscle layers,

Fig. 1. Steps of the per-oral endoscopic pyloromyotomy. (A) Initial endoscopic inspection. (B) Mucosotomy. (C) Submucosal tunnel formation and extension. (D) Identification to the pyloric ring. (E) Pyloric myotomy. (F) Mucosal closure.

Fig. 2. Examples of most commonly utilized endoscopic needle knives. (A) Triangle tip knife. (B) Hybrid knife (T/I). (C) Hook knife. Images courtesy of Olympus America (A, C) and ERBE Elektromedizin GmbH (B).

as the mucosal layer is thicker than what is encountered during esophageal per-oral myotomy and significant hypertrophy of the circular muscle layer can be encountered during the myotomy step. The I-type and T-type hybrid knives allow for simultaneous injection and cautery, minimizing need for knife removal and replacement with the spray catheter (utilized during the submucosal tunnel) decreasing the overall procedural time. The hook knife allows for excellent control particularly during the myotomy phase of the procedure, as the J shape of the knife allows for easy separation of the circular and longitudinal fibers and fine control of coagulation to prevent accidental mucosal injury during coagulation. We primarily utilize a TT (triangle tip) endoscopic knife (KD640L; Olympus) using EndoCut Q setting at 50 W, effect 2 (VIO300D; ERBE) to create a 1 to 1.5 cm transverse mucosal incision above the submucosal injection.

The proper mucosotomy orientation is also not well defined nor described. Several authors^{30,31,33} describe a longitudinal incision analogous to the incision utilized in POEM. We employ a transverse incision that we feel facilitates an easier endoscopic closure with sutures. Again, no comparison of either mucosotomy technique has been employed and it is unclear if either position promotes a potential benefit or reduction in adverse events.

Submucosal tunnel formation and extension

Following the mucosotomy, the distal cap of the endoscope is advanced into the defect. Our practice is to utilize the mechanical force of the cap to 'spread' the mucosa away from the submucosa. This is then followed by further dissection of the submucosal fibers. Our practice is to dissect away from the mucosa almost immediately until the circular muscle fibers are identified. Dissection is then performed immediately above the muscle fibers, with care to prevent accidental muscle injury. For our submucosal dissection we use either the TT or IT-nano (KD 604L or KD 612L; Olympus) endoscopic knives, based on anatomic orientation via spray coagulation mode (50–80 W, effect 2) or forced coagulation mode (50–80 W, effect 2). For any small submucosal vessels, our device settings are changed to soft coagulation (50–80 W, effect 3) or forced coagulation (10 W, effect 1) until complete obliteration of the vessel is seen, then dissection proceeds with the previous settings. Any large or obstructing vessels that are felt to not adequately be treated via the dissecting knife are cauterized using coagulation graspers (FD 410 LR; Olympus) in soft coagulation mode (80 W, effect 3). Our technique is to grasp the vessel and coagulate while attempting to draw the vessel away from the muscle and mucosal layers as to prevent accidental mucosal or muscle injury.

Additionally, re-application of lifting solution is intermittently applied via a spray catheter to expand the submucosal plane and better demarcate the mucosa and submucosal layers. Frequent re-orientation is also performed to ensure correct trajectory and assess proximity to the pylorus via exiting the tunnel and identi-

fying the submucosal dye's discoloration effect on the overlying mucosa. When both the oblique fibers of the pylorus and evidence of submucosal dye at the pyloric ring and in the duodenal bulb are seen, we then transition to execution of the pyloric myotomy. Submucosal dissection in the region of the pyloric ring should be performed with caution since the area can have extensive submucosal fibrosis, especially if previous pyloric directed therapies have been employed (such as botulinum toxin injections or endoscopic balloon dilations). Furthermore, the duodenal mucosa is extremely thin and can be easily perforated, even while performing submucosal injection. If extensive fibrosis exists, we routinely use an IT-nano knife to perform the submucosal dissection in the region of the pylorus.

Myotomy

Following accurate identification of the pyloric ring muscle fibers we begin the endoscopic pyloromyotomy. This is accomplished first with dissection of the circular muscle ring. It is unclear based on the available data if authors employ a 'full thickness' myotomy with dissection of the longitudinal muscle fibers in addition to the circular muscle layers or a 'partial myotomy' of the circular muscle fibers alone, with Jacques et al²⁹ as the only authors that note definitive completion of a full thickness myotomy for all patients, although higher rates of muscle injury were reported. All authors note a myotomy length range between 2 to 4 cm. It is our practice to perform a circular myotomy (again using either the TT or IT-nano endoscopic knives with an EndoCut Q current [50 W, effect 2]) without cutting through the serosal layer due to the extensive vascularity that exists on the serosal surface. Additionally, following myotomy we note the development of a subtle mucosal 'depression'. This depression typically extends the length of the myotomy. We use this, mixed with the endoscopic appearance of the pylorus to help guide the extent of our current myotomy and need for further dissection.

Closure

Following completion of the myotomy, the mucosotomy site is then closed. The various devices used to facilitate closure are endoscopic clips or endoscopic suturing.^{23–33} The decision of which may be predicated on previous technical decisions including the orientation or location (lesser/greater curvature) of the mucosotomy and cost. If clips are the desired closure methods, they are employed in a zipper-like fashion similar to closure of the POEM procedure. Good tissue approximation without evidence of leak should be noted. It is our practice to close the mucosotomy using an endoscopic suturing device (OverStitch™ Endoscopic Suturing System; Apollo Endosurgery Inc., Austin, TX, USA). Lavage and visual inspection are utilized to ensure good tissue approximation and closure.

Technical Tips

A balance of utilization and avoidance of carbon dioxide insufflation is essential throughout the procedure. Too much insufflation may result in the development of capnoperitoneum that may require needle decompression vs too little (especially near the pyloric ring) will impair visualization, promote mucosal prolapse into the tunnel and predispose to the creation of accidental mucosal injury.

If a mucosal injury is identified at any time during the procedure, attempts to close the defect should be employed prior to the end of the procedure. We find that the defects are typically small and amendable to endoscopic clipping. The defect can sometimes be small and difficult to visualization. To help aid in detection of these lesions we aspirate all of the free floating fluid followed by selective spray injection of the dye solution into the submucosal tunnel followed by observation of 'dye leak' on the mucosal side.

Identification of the pyloric ring can be more challenging than in the identification of the gastroesophageal junction in esophageal myotomy. This typically is due to extensive fibrosis that can be present in the region of the pylorus as mentioned above making dissection of the submucosal layer difficult and distorting the appearance of the pyloric muscle.

Postoperative course

Typically patients are observed overnight in a hospital setting. The average length of stay across the largest G-POEM studies was 2.6 days. In 7/12 of these studies an upper gastrointestinal series (GI series) was obtained on postoperative day 1 to assess the mucosal integrity of the closure.^{26-28,31-33} If no mucosal leak was identified, diet was advanced.

Six of the 12 studies employed use of twice-daily proton pump inhibitor therapy to promote mucosotomy site healing and prevent pyloric channel ulceration.^{23,24,26,27,31,33} Three studies provide 5 days of oral antibiotic therapy.^{30,31,33} Postoperative diet recommendations are heterogeneous, although a graded approach is typically utilized with initiation of clear liquids for a set duration followed by slow advancements to a solid gastroparetic diet.²³⁻³³ We employ similar diet recommendations as Mekaroonkamol et al³³. Following admission for observation and anti-nausea medications patients are kept *nil per os* immediately following the procedure until a limited upper GI series confirms an absence of a mucosal leak. Following this, a full liquid diet for 72 hours is employed, followed by a soft diet for 4 days, followed by advancements to a regular gastroparetic diet (small volume, soft, frequent meals) one week post procedure. Our patients are discharged on twice a day proton pump inhibitor for 4 weeks with 5 days of oral ciprofloxacin or equivalent therapy. Our average length of hospitalization is 1 to 2 days. Repeat gastric emptying, pyloric distensibility and symptom assessment is typically obtained 8 to 12 weeks post procedure.

Adverse Events

The most common adverse events reported are capnoperitoneum, antral/pyloric ulceration with and without bleeding, pyloric stricture formation and perforation.²³⁻³³ Capnoperitoneum is secondary to excessive insufflation during submucosal tunnel dissection and pyloromyotomy and rarely requires intervention, although for severe symptomatic cases, needle decompression is typically utilized. Antral or pyloric ulceration, with or without bleeding, can be seen secondary to mucosotomy closure site

break down and the aim of treatment is to utilize medications to suppress stomach acid production (proton pump inhibitor or H2-blocker medications) and promote improved mucosal integrity (sucralfate) with or without endoscopic hemostasis and supportive care. Pyloric channel stricture formation is likely a sequelae of either untreated or undertreated ulceration. In our experience, pyloric channel stricture is amendable to serial endoscopic balloon dilations. Perforations secondary to inadvertent muscle and mucosal injury, as mentioned above, are typically able to be managed endoscopically without the need for surgical intervention.

Conclusion

The G-POEM or POP procedure is being increasingly performed for medically refractory gastroparesis thought to be due to pylorospasm. While no standardized approach to the procedure has been developed this review outlines current consensus and variability reported by the currently available literature. Although preliminary studies demonstrate promising results from G-POEM, future multi-center randomized control trials evaluating outcomes are needed to assess the safety and efficacy of this new procedure.

Conflicts of Interest

Alexander Podboy reports no potential conflict of interest relevant to this article.

Joo Ha Hwang is a consultant to Olympus, Medtronic, and Micro-Tech.

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